Aging Brain and Insulin Resistance

2025-10-24

```
knitr::opts_chunk$set(echo = TRUE)
    library(imager)
```

```
## Warning: package 'imager' was built under R version 4.4.3
```

```
## Loading required package: magrittr
```

```
## Warning: package 'magrittr' was built under R version 4.4.3
```

```
##
## Attaching package: 'imager'
```

```
## The following object is masked from 'package:magrittr':
##
##     add
```

```
## The following objects are masked from 'package:stats':
##
##     convolve, spectrum
```

```
## The following object is masked from 'package:graphics':
##
##     frame
```

```
## The following object is masked from 'package:base':
##
##     save.image
```


Abstract

Brain aging is a natural process that is linked to reduced cognitive abilities, brain volume and neurochemical activity. There are many ways to slow this process down, one of them being diet. The question we seek to answer is "Can keeping a healthy weight and lower insulin resistance help prevent brain aging?". To answer this question, we conducted an analysis on data from an fMRI study of the aging brain on acute ketosis, using scatterplots to see if BMI vs HOMA and age vs HOMA are related.

Introduction

As we continue to age and develop, our brain does too. According to the National Institute of Aging (NIA), brain aging is a natural process that happens over time that affects cognitive function. With brain aging comes slower recall, diminishing working memory and multitasking abilities, deterioration of the myelin sheath, shrinking brain regions, and less production of neurotransmitters like dopamine and serotonin. Although brain aging is inevitable throughout our lives, there are ways to slow the process down such as getting an adequate amount of sleep, effectively managing stress, and engaging in mentally stimulating activities. For our report, we plan to look into how diet can play a factor in slowing brain aging. The question we seek to answer in our analysis is "Can keeping a healthy weight and lower insulin resistance help prevent brain aging?".

Our analysis may benefit anyone who is concerned about their aging brain and want to keep their brains young and healthy for longer than average. It would be especially beneficial for older and elderly adults since they have a higher risk of developing neurodegenerative diseases like Alzheimer's and Parkinson's disease, which can accelerate brain aging. Looking at body weight index (BMI) and HOMA-IR (Homeostatic Model Assessment for Insulin Resistance) scores would help us understand how diet is related to brain aging in different age groups. Analyzing these variables could help people realize what they should change in their diet by adding or subtracting certain foods in their meals. This would be a step in keeping the brain and body healthy as both are interlinked.

To answer our question, we plan to use the data from an fMRI study of the aging brain in acute ketosis. We plan to create scatterplots from the data to analyze the relationships between BMI vs HOMA and age vs HOMA.

Data

To perform our analysis, we used data from an fMRI study of the aging brain in acute ketosis, which was found from openneuro.org, an open-source platform with public datasets containing neuroimaging data. The study involved scanning participants in a fasted state before and after they were administered insulin or glucose bolus based on body weight. Our data consists of 101 participants, aged 21-79, with the variables, participant_id, age, sex, BMI, bodyweight, fasting insulin (administered before or after), HbA1C, and HOMA.

Data Cleaning

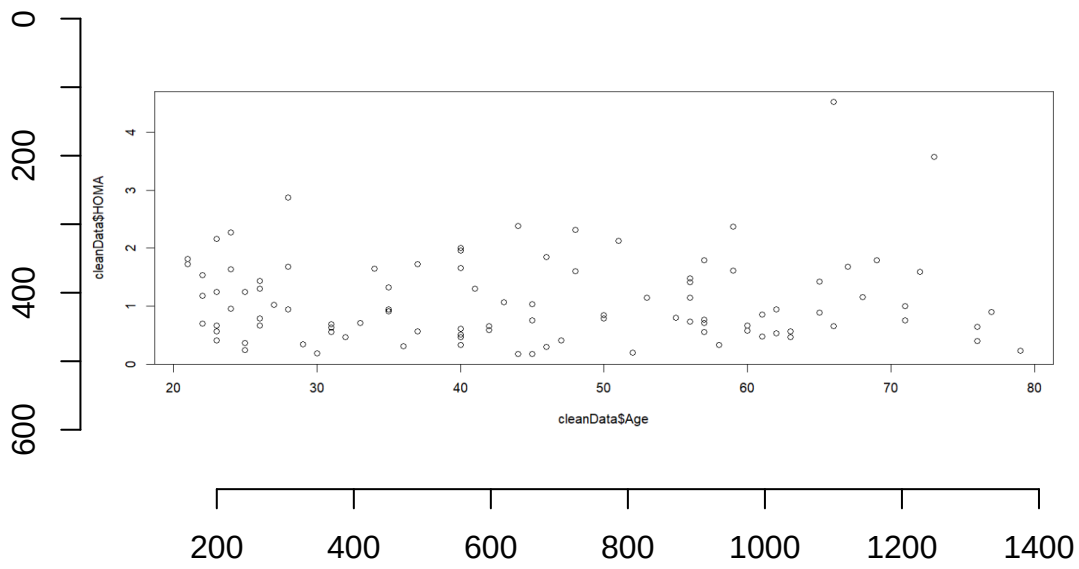
To clean the data, variables irrelevant to our analysis like sex, bodyweight, and HbA1C were first removed before capitalizing the variable names to a more uniform syntax for easier reference. The data types for the remaining variables were converted for compatibility with Age, BMI, Fasting Insulin, and HOMA being numeric variables and Participant_ID being a categorical variable. We also removed observations that had missing values, leaving us with a filtered data set of 99 observations containing data for Participant_ID, Age, BMI, Fasting Insulin, and HOMA.

Visualizations

HOMA is a score combining glucose + insulin. when HOMA is high that means bad glucose fuel(insulin resistance) which can relate to brain aging.

Hypothesis1: "if age is older then HOMA will be increase"

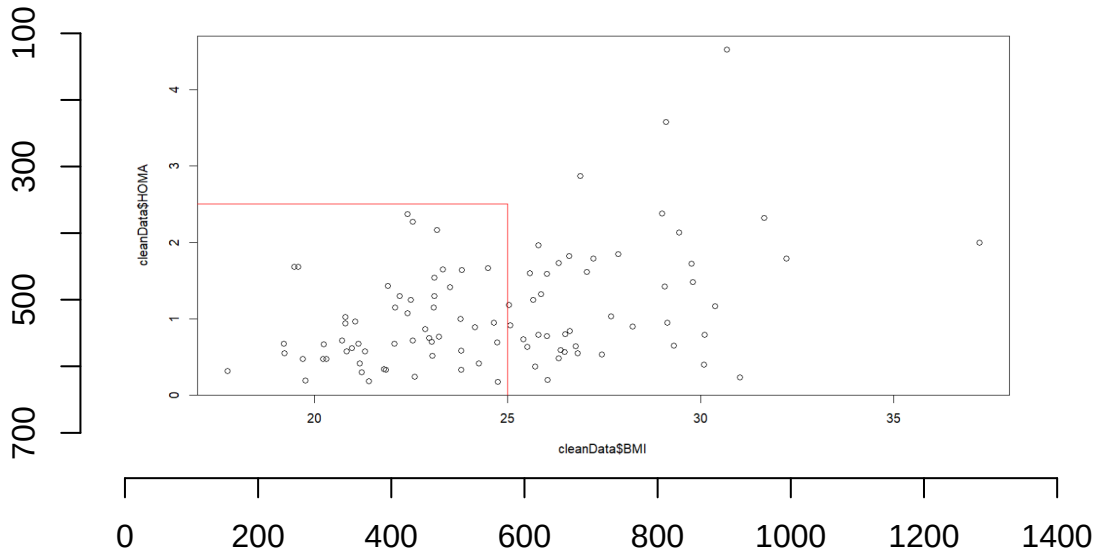
Create scatter plot to visualize the age relate to HOMA.



According to scatter plot of age and HOMA, we can observe HOMA is not really affected by age. Red line indicates high HOMA which means faster aging, yet data shows HOMA is not really related to age.

Hypothesis2: if BMI is higher, does HOMA increases as well.

Create the scatter plot displays BMI with HOMA.

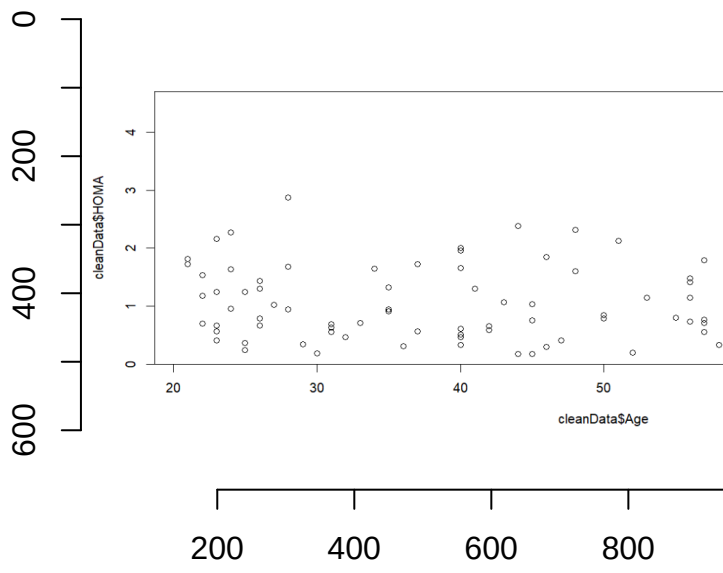


Shows higher the BMI, HOMA tends to increase as well. Red line indicates high HOMA. According to scatter plot, as BMI increases, HOMA increases as well.

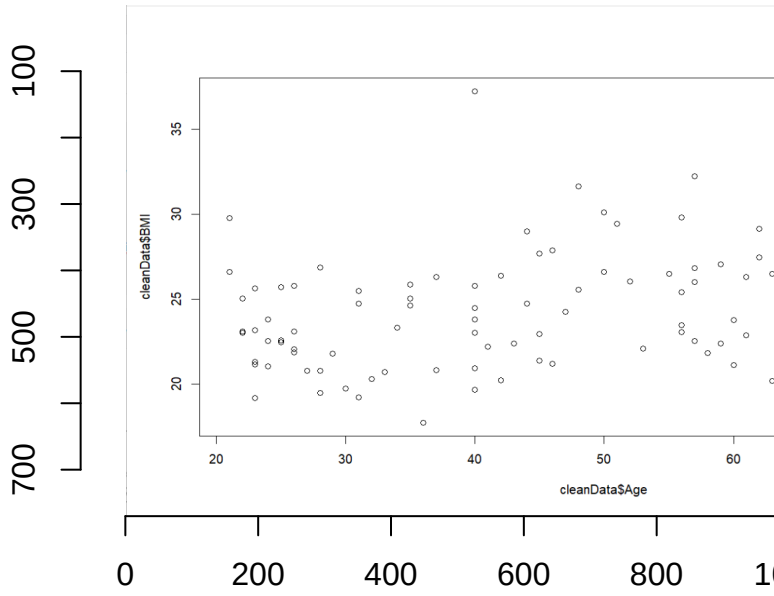
high HOMA which can be high insulin resistance = glucose fuel less efficiently - brain's activity is depends on glucose, its main fuel source. - less efficient it is, there is high possibility that brain can aging faster.

Expected outcomes for age & HOMA, we are expecting older the age = higher the HOMA for hypothesis 1, and for BMI & HOMA, we are expecting higher the BMI = higher the HOMA according to data we have and visualized scatter plot graph, we could observe age is not really related to HOMA, yet BMI is relevant to HOMA. As BMI increases, HOMA increases as well.

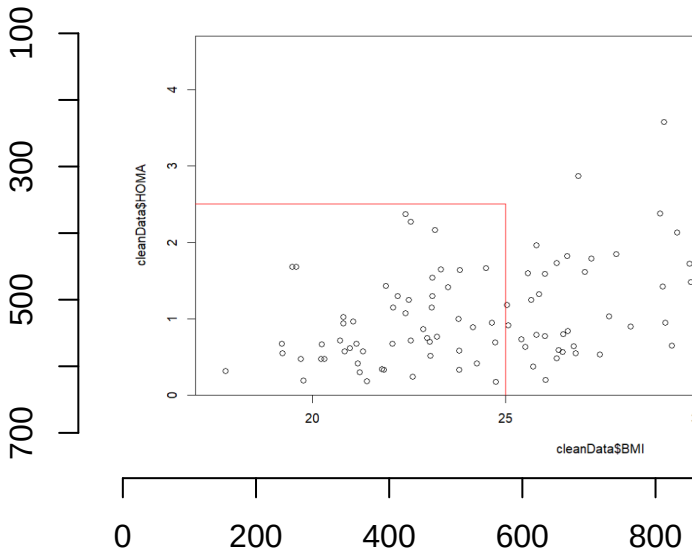
Analysis



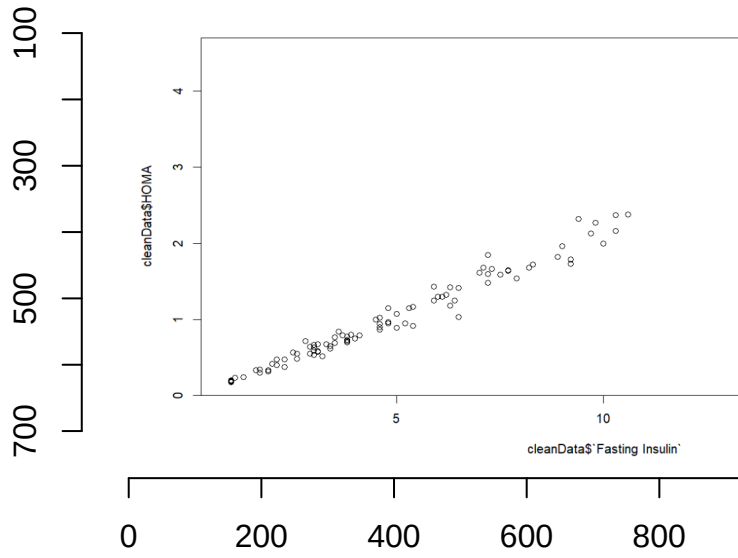
Age and HOMA plot (p-val = 0.7141, cor = 0.03728332)



Age and BMI plot (p-val = 3.75e-05, cor = .401814)



BMI and HOMA plot (p-val = 5.156e-05, cor = 0.3952093)



Fasting Insulin and HOMA (p-val = 2.2e-16, .9870984)

We performed correlation testing on our relevant variables such as age vs. HOMA, HOMA vs BMI, and fasting insulin levels vs. BMI. The test between age and HOMA proved to be not significant as the p-value = 0.7141 indicating that there was no true correlation between the two.

However fasting insulin vs BMI and HOMA vs BMI had p-values less than 0.5 indicating that there was a correlation between the two. HOMA and BMI had a correlation of 0.3952 indicating a weak correlation but it still did exist.

Fasting insulin and BMI had a correlation of 0.4109 indicating a moderate correlation between the two.

Age and BMI had a statistically significant correlation as well with a value of .4018 indicating another moderate correlation.

Conclusions

Overall, age did not really matter to HOMA, while BMI was affecting HOMA. Since we mentioned about how high HOMA equates to bad glucose fuel and higher insulin resistance, and how brain activity is dependent on glucose that is the main fuel source. The higher BMI is, the higher HOMA will be, which prevents the brain from aging faster. At the same time, if an individual has a normal or lower BMI, it can give better insulin sensitivity that can lead to a healthier brain. Insulin works well with healthy BMI; the brain gets steady fuel supply. With that, we are able to answer our prompt: "Can keeping a healthy weight and lower insulin resistance help prevent brain aging?". Based on our data and analyses, we can conclude that keeping a healthy weight most likely results in a healthy BMI that supports lower insulin resistance which can help prevent brain aging.

Member Contribution

Jonathan Wu - Formatting, Cleaning, ReadME Sung Woo - Data Visualization, Analysis Christie Wong - Report(Abstract, Intro, Data)